CONTINUOUS VACUUM PAN

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of the U.S. national stage designation of copending International Patent Application PCT/IB01/00942, filed May 30, 2001, the entire content of which is expressly incorporated herein by reference thereto.

FIELD OF THE INVENTION

This invention relates to a continuous vacuum pan for crystallizing the solute of a solution.

BACKGROUND TO THE INVENTION

U.S. Patent No. 3,880,593 to Windal describes a crystallization apparatus in the form of a cylindrical tank with a floating calandria or a fixed calandria. A lower portion of the tank has radially extending dividing walls to define therebetween a plurality of compartments located in series with one another. The dividing walls have ports at their bases to permit the continuous flow of a solute containing solution from one compartment to the other. The bottom of the tank has an inverted V-shape. Feeding means for feeding an undersaturated solution of the solute into successive compartments is arranged in an upper portion of the tank for rotation about the vertical axis of the tank to sweep over successive compartments. Shutters are provided for controlling the amount of the undersaturated solution fed to each of the compartments.

South African patent 84/6920 to the applicant describes a continuous vacuum pan crystallizer which is essentially a long path horizontal vessel with vertical tube floating calandrias in each compartment.

It is an object of this invention to provide an improved continuous vacuum pan.

SUMMARY OF THE INVENTION

According to the invention a continuous vacuum pan includes:

a cylindrical housing having a vertical axis;

at least one liquid heating pan within the housing;

a vertical tube, floating calandria within the liquid heating pan, the vertical tube floating calandria having a downcomer between its periphery and the periphery of the liquid

heating pan, with a gap between the bottom of the calandria and the bottom of the liquid heating pan;

radially extending baffles in the liquid heating pan defining a plurality of compartments located in series with one another, the compartments ranging from a first upstream compartment to a downstream output compartment; and

ports in all of the baffles, except in the baffle between the output compartment and the first compartment, the ports being spaced from the bottom of the liquid heating pan and permitting communication between the compartments.

The ports may be located above the bottom of the calandria and preferably above the top of the calandria. Guiding baffles may be provided for guiding the liquid from the ports onto the periphery of the calandria or directly into the downcomer.

The bottom of the liquid heating pan may be substantially W-shaped.

The cylindrical housing may be a circular cylindrical housing and the vertical tube floating calandria may be circular in plan view.

The pan preferably includes a vertically extending heating fluid conduit, for supplying heating fluid to the calandria. The vertical axis of the heating fluid conduit preferably coincides with the vertical axis of the housing.

Each compartment preferably has its own feed or solution inlet for feeding solution separately and simultaneously into each compartment.

The pan may include two liquid heating pans comprising an upper liquid heating pan located above, and in series with, a lower liquid heating pan. It will be appreciated that the pan may include more than two liquid heating pans, with the liquid heating pans being stacked one on top of the other.

A downstream output compartment of the upper liquid heating pan preferably communicates with a first upstream compartment of the lower liquid heating pan.

The upper and lower liquid heating pans are preferably in vapour communication with one another so that vapour generated by the heating of the liquid in the lower pan can be removed from the lower pan together with vapour generated by the heating of the liquid in the upper pan via a common vapour zone located above the upper pan.

The vapour communication may be achieved by at least one peripherally extending passageway located between the housing and the upper pan. Alternatively, the vapour communication may be achieved by ducts located externally to the housing. Yet further alternatively, the vapour communication may be achieved by a plurality of conduits located between the housing and the upper pan, each conduit being in communication with its own compartment in the lower pan.

According to another aspect of the invention a method of crystallizing the solute of a solution by evaporating the solvent of the solution in a continuous operation in a vacuum pan having a plurality of compartments located in series with one another and divided from one another by radially extending baffles, the compartments ranging from a first upstream compartment to a downstream output compartment, the method including the steps of heating the solution within each compartment via a vertical tube floating calandria so that the solution will flow upwardly through vertical tubes of the calandria, across the top of the calandria, downwardly through a downcomer between the periphery of the calandria and the periphery of the compartment along a gap between the bottom of the calandria and the bottom of the compartment, and back into the vertical tubes of the calandria, and discharging excess solution from upstream compartments to downstream compartments through ports in the baffles onto the calandria towards the periphery of the calandria or directly into the downcomer.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a partly cut away side view of a vacuum pan according to the invention with an internal condenser;

Fig. 2 is an enlarged view of the vacuum pan of **Fig. 1**;

Fig. 3 is a cross-sectional plan view on line III-III of **Fig. 2**;

Fig. 4 is a cross-sectional plan view on line IV-IV of **Fig. 2**;

Fig. 5 is a cross-sectional plan view on line V-V of **Fig. 2**;

Fig. 6 is a cross-sectional side view of a vacuum pan according to another aspect of the invention;

Fig. 7 is a cross-sectional plan view on line VII-VII of **Fig. 6**;

Fig. 8 is a cross-sectional side view of a vacuum pan according to a further aspect of the invention;

Fig. 9 is a cross-sectional plan view on line IX-IX of **Fig. 8**;

Fig. 10 is the same view as **Fig. 3** but with modified small baffles on either side of the ports; and

Fig. 11 is the same view as **Fig. 4** but with modified small baffles on either side of the ports.

Detailed Description of the Drawings

A double calandria continuous vacuum pan **10** with an integral condenser **12** is shown in **Fig. 1**.

Referring now to **Figs. 2** to **5**, the pan **10** includes an outer housing **14**, a lower massecuite heating pan **16**, an upper massecuite heating pan **18**, and a centrally located heating vapour conduit **20**. The heating vapour conduit extends along the vertical longitudinal axis **21** of the housing **14**.

The lower and upper pans **16** and **18** each contain a circular, vertical tube, floating calandria **22** and **24** respectively.

The upper pan **18** is divided into six compartments **26.1** to **26.6** by baffles **28**.

The baffles **28** extend radially from the conduit **20**. The compartments **26.1** to **26.6** communicate with one another via ports **30** in the baffles **28**. The ports **30** are located above the top of the calandria **24** and towards the periphery of the calandria **24**.

Small guiding baffles **32** are located one on either side of each port **30**. The compartments **26.1** to **26.6** are thus located in series with one another. The baffles **28** are sufficiently high to prevent liquid mixing between the compartments.

The lower pan **16** is also divided up into six compartments **34.1** to **34.6** by baffles **36**. The baffles **36** do not extend to the roof of the lower pan **16**. There is sufficient space between the top of the baffles **36** and the roof of the lower pan **16** to allow a person to climb over the top of the baffles **36** from one compartment to the other. The compartments **34.1** to **34.6** communicate with one another via ports similar to those between the baffles in the upper compartments **26.1** to **26.6**. As can be seen from **Figs. 3** and **4**, the compartments in the upper pan **18** are angularly offset relative to the compartments in the lower pan **16**. This angular offset allows the upper compartment **26.6** to communicate with the lower compartment **34.1** by conduit **40**. Thus the upper compartments are located in series with the lower compartments. The flow of massecuite through the compartments is indicated by arrows **42**.

As can be seen from the arrows **42**, the massecuite is directed onto the calandria towards the periphery of the calandria by the small guiding baffles **32**. The small guiding baffles **32** may however be arranged so that the massecuite is directed directly into a downcomer **78** as can be seen in **Figs. 10** and **11**. In **Figs. 10** and **11**, the small baffles are indicated by reference numeral **32.1** and the flow of massecuite is indicated by reference numeral **42.1**.

It will be appreciated that the compartment **26.1** is a first upstream compartment of the upper pan, and the compartment **26.6** is a downstream output compartment of the upper pan. Likewise the compartment **34.1** is a first upstream compartment of the lower pan, and the compartment **34.6** is a downstream output compartment of the lower pan.

The upper and lower pans can each be divided into more than six compartments or into less than six compartments.

The lower pan **16** is in vapour communication with the upper pan **18** via circumferentially extending passageways **44** located between the upper pan **18** and the outer housing **14**. The passageways **44** discharge into a common vapour zone **45** located above the upper pan **18**.

The heating vapour conduit **20** communicates with each calandria **22** and **24** via apertures **46** in the conduit **20**.

The calandrias **22** and **24** each have non-condensible gas collection pipes **48** connected to outlet pipes **50** through which the non-condensible gases are removed from the calandrias. Condensate is removed from the calandrias via pipe **51**. The non-condensible gas collection pipes **48** may be in ring form as shown or a number of radially extending pipes may be used instead. The collection pipes **48** may be of different lengths to improve their collection of non-condensible gases.

A breather tube **52** is provided for conveying non-condensible gases which collect in a conical zone **54** of the lower compartment to the common vapour zone **45**.

Each compartment in the upper pan **18** has a sugar solution or water inlet in the form of a pipe **56** discharging into a distributor box **58**.

The upper compartment **26.1** has a seed inlet in the form of a pipe **60**. The seed consists of sugar crystals in syrup. The seed may be introduced into the top or the bottom of the upper compartment **26.1**.

Each compartment in the lower pan **16** has jigger steam inlets in the form of pipes **62**, and a single sugar solution or water inlet in the form of a pipe **64** discharging into a distributor box **66**. Jigger steam inlets may also be fitted to the compartments in the upper pan **18**.

A massecuite outlet box **68** is provided adjacent the lower compartment **34.6**. The outlet box **68** contains an adjustable height weir **70** for varying the position of the massecuite level in the lower pan **16**. The massecuite level in the upper and lower pans is shown by lines **72**. The height of the conduit **40** can be adjusted to vary the level of the massecuite in the upper pan **18**.

Both the upper and lower pans have substantially W-shaped bottoms **74** to facilitate the flow of massecuite therein. The substantially W-shaped bottoms of the upper and lower pans ensure that there is an adequate circulation of the massecuite and also ensure that the heating surface to volume ratio is correct.

In use, the massecuite in each compartment flows upwardly from the bottom of the pan through vertical tubes **76** in the calandrias, over the top of the calandria to the outer edge of the calandria and downwardly through an annular gap or downcomer **78** between the calandria and the outer housing, along the W-shaped bottom **74** and back up into the vertical tubes **76**. Excess massecuite is discharged into the next compartment through the port **30** in the baffle. Thus when viewed from the top of the pan (**Figs. 3** and **4**), the massecuite flows in a substantially circular path from compartment to compartment. When each compartment is viewed in cross-sectional side view, the massecuite in each compartment also flows in a substantially circular path. For the sake of clarity arrows **43** in **Fig. 6** illustrate the substantially circular flow path when each compartment is viewed from the side in cross-section.

The successive compartments are filled from above the calandria, with the massecuite entering each compartment being directed towards the periphery of the calandria or by being directed directly into an annular gap or downcomer **78** located between the periphery of the calandria and the periphery of the compartments. The introduction of the massecuite into successive compartments towards the periphery of the calandria or directly above the downcomer **78** reduces the possibility of the vertical tubes of the calandria being filled from the top, and also prevents short circuiting of the massecuite from one compartment to the next.

It will be appreciated that the use of vertical tubes in the floating calandrias in conjunction with the substantially W-shaped pan bottoms are important to ensure the correct circulation of massecuite in each compartment.

Vapour generated as the massecuite boils flows upwardly from each of the lower compartments through the circumferentially extending passageways **44** to the common vapour zone **45** where, together with the vapour generated in the upper compartments, it is drawn off into the integral condenser **12** and condensed to maintain a pressure in the pans which is lower than the ambient pressure. Instead of an integral condenser **12**, an external condenser may be utilized.

The massecuite within the pans is maintained in a super-saturated condition to ensure crystallization of the sugar. The massecuite flows from one compartment to the next in substantially plug flow fashion to enhance the crystallization process.

Each compartment in the upper and/or the lower pans may have a water spray system (not shown) to wash down encrustation on the surfaces of the compartments. The water feed to the spray system may be intermittent and it may be controlled by a timer or by an operator.

Referring now to **Figs. 6** and **7**, a vacuum pan **10.1** is the same as vacuum pan **10** except, instead of the vapour passageways **44**, it has three external ducts **80**. The inlet to each external duct **80** straddles a pair of compartments in the lower pan. Thus the number of ducts is equal to half the number of compartments.

Referring now to **Figs. 8** and **9**, a vacuum pan **10.2** is the same as the vacuum pan **10** except, that instead of the vapour passageways **44**, it has quarter-round, vapour conduits **82**. Each compartment in the lower pan has its own vapour conduit **82** as can be seen from **Fig. 9**.

It will be appreciated that many modifications or improvements of the invention are possible without departing from the spirit or scope of the invention.